City of Sault Ste. Marie

# Sault Ste. Marie Solid Waste Environmental Assessment
# Surface Water Impact Assessment and Mitigation (Draft)


**Prepared by:**

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**Project Number:**

60117627

**Date:**

October 2015

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October 5, 2015

Ms. Catherine Taddo, P. Eng.
Engineering Department
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99 Foster Drive, 5th Floor
Sault Ste. Marie, ON P6A 5N1

Dear Ms. Taddo:

**Project No:** **60117627**

**Regarding:** **Sault Ste. Marie Solid Waste Environmental Assessment**
**Surface Water Impact Assessment and Mitigation**

We are pleased to submit our Surface Water Impact Assessment and Mitigation Report which has been prepared to support a proposed expansion of the existing municipal landfill located on Fifth Line.

The surface water impact assessment examines and evaluates the potential for impacts on surface water resources from the proposed landfill development. This is achieved through the analysis of the potential effects of landfill development on surface water quality and water quantity (flood hazard).

Sincerely,
**AECOM Canada Ltd.**

Rick Talvitie, P. Eng.
Manager, Northern Ontario
RT:nm
Encl.

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# Revision Log

| Revision # | Revised By | Date | Issue / Revision Description |
|---|---|---|---|
| 0 | R. Talvitie | January 29, 2015 | DRAFT for City staff review |
| 1 | R. Talvitie | October 5, 2015 | Revised DRAFT |
| | | | |
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# 1. Introduction and Background

## 1.1 Background

This document presents the findings of the surface water assessment as part of the Environmental Assessment (EA) of the proposed expansion of the City of Sault Ste. Marie's landfill located on Fifth Line. The proposed project includes an expansion of the disposal boundaries to the north and west and a moderate increase in the height of the waste. Landfill mining is also proposed within the western portion of the existing disposal footprint to facilitate the construction of a liner to enhance environmental management at the site. The mining process involves excavation of waste within the existing disposal footprint, removing fines and recyclables, transferring the residual waste to a new lined cell and lining the mined area to accommodate future waste disposal. The planned expansion will be accommodated within existing City owned lands.

The role of the surface water impact assessment is to examine the potential for impacts on surface water resources from the proposed landfill development. This is achieved through the analysis of the potential effects of landfill development on surface water quality and water quantity (flood hazard). The preparation of a surface water management strategy will include stormwater management (SWM) measures that mitigate these impacts. The SWM measures reflect the guidelines and recommendations in the City of Sault Ste. Marie's recent document *Stormwater Management Guidelines – City of Sault Ste. Marie (R.V. Anderson 2014).*

Following this introductory section, the report takes on the following format:

- Description of the preferred expanded disposal footprint;
- Outline of the study approach and methodology;
- Information sources considered;
- Comparison of existing and proposed storm water management conditions;
- Surface water net effects;
- Overview of proposed storm water management plan; and
- Required approvals.

## 1.2 Objectives of Surface Water Impact Assessment

. The specific objectives guiding the investigations and analyses undertaken are as follows:

- Determine the existing conditions at the proposed site (recharge areas, floodplains, drainage) and along the receiving watercourses in terms of hydrologic characteristics (peak flows and runoff volumes) and surface water quality characteristics.
- Establish specific surface water goals and objectives for the new landfill expansion.
- Develop an appropriate surface water management plan comprising Best Management Practices (BMPs), conveyance and containment systems and operational practices to achieve the established objectives.
- Define any residual or net effects on surface water quality and quantity which may persist during the landfill facility operations and post-closure.
- Review and modify the existing surface water monitoring plan as required to account for the new landfill expansion.

# 2. Description of the Preferred Alternative Landfill Footprint

There is currently one operating landfill site in Sault Ste. Marie, located on **Figure 1,** at 402 Fifth Line East, owned and operated by the City of Sault Ste. Marie.

In the preceding Alternative Methods phase of the EA, a comparative evaluation of the four alternative landfill footprint options was carried out in order to identify a Preferred Alternative Landfill Footprint.

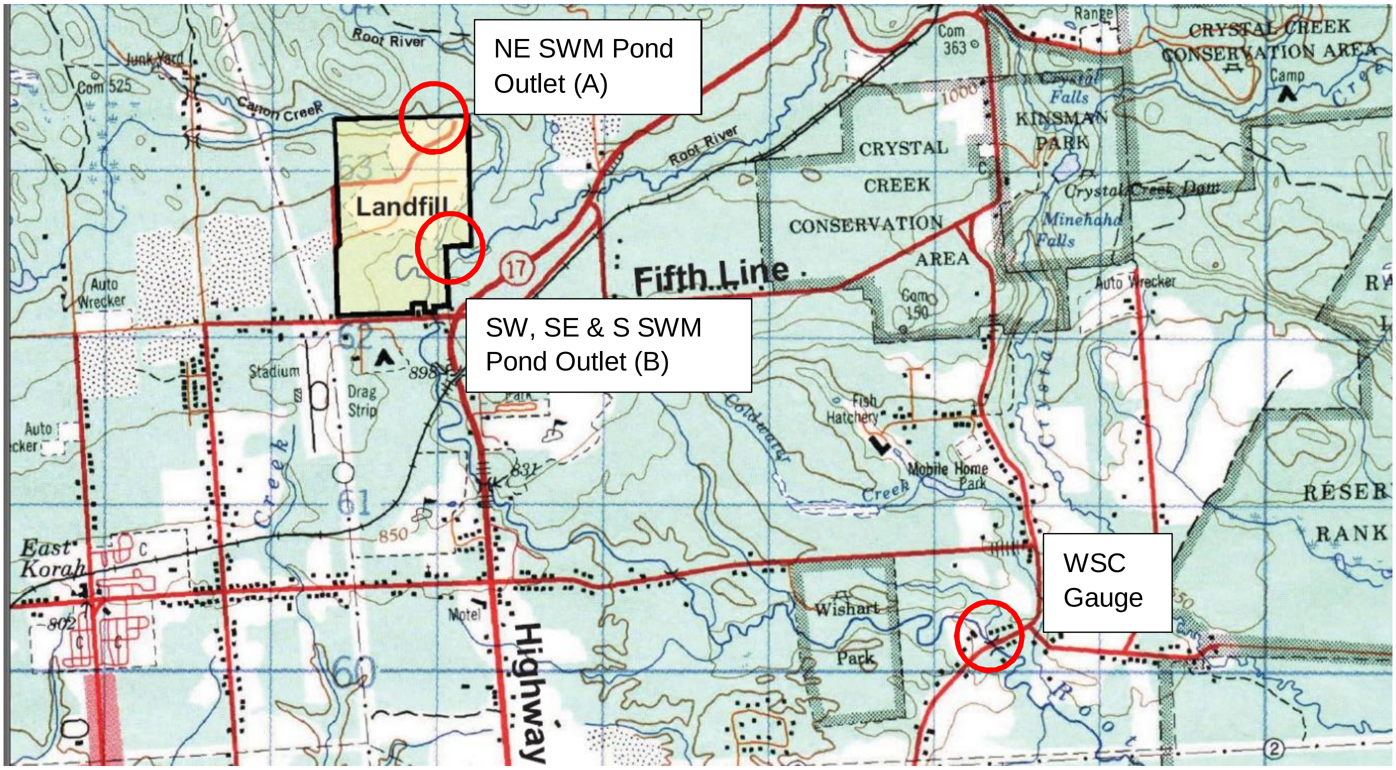
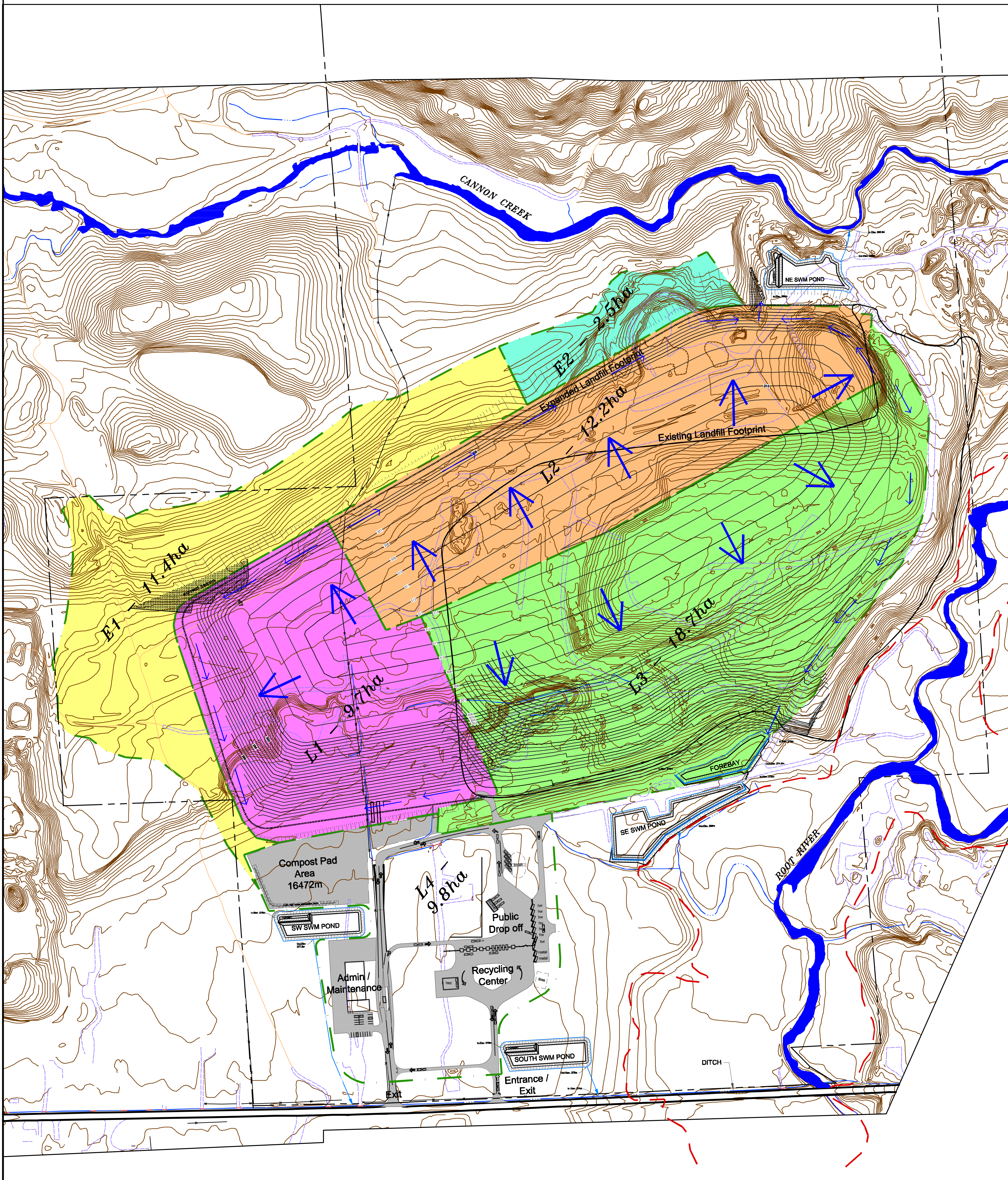



**Figure 1 – Location**

The preferred alternative landfill footprint was determined to be Option #3 – West and North Expansion B with landfill mining, as illustrated in **Figure 2**. This option includes the expansion of the landfill from the western edge of the existing site towards the hydro corridor and a northern expansion from the northern limit of the existing landfill. It also includes a vertical expansion of 4 m and landfill mining within the western portion of the existing disposal footprint to facilitate the construction of a liner to enhance environmental management at the site.

The final contours of the landfill expansion are also shown in **Figure 2**. The contours reflect a maximum elevation (top of final cover) of 314.0 m with a maximum side slope of 4H to 1V. The total footprint area of the landfill expansion is approximately18 ha.




## LEGEND

- CATCHMENT AREAS
- DITCH
- FLOODPLAIN (100 YEAR)
- OUTLET SWALE
- PAVEMENT

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# Figure 2

## Sault Ste. Marie Municipal Landfill Site

COMMISSIONER OF ENGINEERING & PLANNING
JERRY DOLCETTI

# 3. Study Approach and Methodology

## 3.1 General

This section summarizes the approach and methodologies adopted to establish the existing conditions, to predict potential impacts, to identify alternative mitigation measures and evaluate their effectiveness, and to recommend the most suitable measures for implementation.

To assess the potential impacts of the proposed landfill expansion on surface drainage, hydrologic analysis was undertaken:

- To establish the peak flow rates and runoff volumes generated from the proposed site;
- To define the hydrologic regime in the receiving streams adjacent to the site;
- To identify any potential surface water quality impacts from site drainage associated with the expansion;
- To identify any potential surface water quantity impacts from site drainage associated with the expansion;
- To identify any internal drainage requirements including roadway ditch capacities.

Suitable mitigation measures were developed, at a conceptual level, that will mitigate any identified impacts. These are identified in Section 6 and are conservative estimates of volumes and areas required for impact mitigation.

## 3.2 Methodology

In order to quantitatively estimate runoff flows and volumes and to assess the effects of changes within a drainage area (land use and drainage patterns) a hydrologic model is required. For the evaluation of hydrologic impacts associated with the proposed landfill expansion, a Visual OTTHYMO (VO2) hydrology model was developed to determine the peak flow estimations at key locations within the Study Area. This is in keeping with City's SWM Guidelines (Anderson 2014).

The estimation of flows in larger watersheds is typically achieved by the statistical analysis of long term flow records. For Canon Creek and the Root River, the *WSC gauge 02CA002–Root River at Sault Ste. Marie* on the Root River provides a convenient source of long term flow record with forty-three (43) years of observed flow data (1971-2013).

### 3.2.1 Hydrologic Modelling

The VO2 software is a single event model which can simulate the rainfall-runoff process from both rural and urban basins. The software responds to the input of a design storm rainfall hyetograph and produces an estimate of the time-history of runoff hydrograph as output. Hydrographs can be generated at selected locations in the watershed.

The VO2 software computes the excess runoff according to the Soil Conservation Service (SCS) method. The runoff hydrograph is determined by the software as a function of physical characteristics of the basin such as drainage area, surface soil type, land use, and channel hydraulics. The hydrographs can then be routed along the watercourses using the variable storage coefficient method, which accounts for the effect of the channel storage. The software can also account for the effect of storage in detention ponds.

The VO2 software requires several watershed parameters as input in order to generate runoff estimates. These parameters are described below:

1. **Drainage Area** – VO2 modelling requires the delineation of the drainage area upstream of the selected locations where the flow calculations are required. These contributing areas are referred to as subareas in this report.
2. **Runoff Curve Number (CN)** – This parameter is used to determine the percentage of rainfall which becomes runoff for a given event. It is based on the land use and soils found within the subarea. For areas less than 20% impervious, VO2 uses the NASHYD routine to determine runoff. This routine was used for the physical landfill and existing drainage areas.
3. **Initial Abstraction (Ia)** – This parameter consists mainly of the interception, infiltration and surface storage of rainfall during the beginning of storm events, before runoff is produced.
4. **Imperviousness (%)** – for areas with significant imperviouseness (rooftops, roads, parking lots), VO2 uses the STANDHYD routine to determine runoff. This routine was used for the Administrative, Recycling and Compost areas.
5. **Time to Peak (Tp)** – This parameter represents the time from the beginning of rainfall to the peak of the hydrograph and is indicative of the basin response to storm events. This parameter is based on physical watershed characteristics such as length, slope and area.

### 3.2.2 Water Quality Consideration

Any proposed stormwater management (SWM) system to service the uncontaminated areas of the existing landfill site and proposed landfill expansion will require surface water quality control, assuming the uncontaminated areas, including the final cover, will be serviced by an internal paved road system, including roadside ditches that could produce impacts related to suspended solids and oil/grease contaminants. Water quality protection as described in the Ministry of the Environment (MOE) Stormwater Management Planning and Design Manual (March, 2003), will be implemented as it relates to Total Suspended Solids (TSS) management and oil/grease traps will be considered at the outlets should site monitoring indicate ongoing and persistent oil/grease contamination. Given the potential for leachate breaches at the site and the possibility of oil/gas spills from landfill operations, the development of an emergency capability for holding and addressing contaminated runoff will also be considered.

### 3.2.3 Water Quantity Consideration

The Root River and its tributary Canon Creek fall under the jurisdiction of the Sault Ste. Marie Region Conservation Authority (SSMRCA).

In accordance with the Conservation Authorities Act, the Conservation Authority is empowered to prohibit or regulate any proposed works within areas susceptible to flooding during a Regulatory Storm. The Regulatory Storm in the areas under the jurisdiction of the SSMRCA is assigned to the higher of the Timmins Storm or the 100-year event.

For the purpose of this report, water surface elevations and regulatory floodplain were extracted from the most recent Root River Study (Dillon 1987), as shown in **Figure 2**. As concluded in the Dillon report, the landfill has a 7 meter freeboard above the Regulatory Flood level and it is evident that the landfill site is not impacted by the Root River or Canon River floodplain.

In terms of surface water quantity control, the analysis provided in Section 5.4 suggests that none is required since the peak flows from the proposed landfill site will have no or negligible impact on peak flows in the receiving watercourse due to both their magnitude and timing.

## 3.3 Study Assumptions

The surface water analyses were based on two key assumptions:

1. The general layout and drainage characteristics of the existing landfill facilities conform to the design concept presented in the Design and Operations Report;
2. The surface water drainage system collects runoff generated from uncontaminated areas; runoff which has come into contact with refuse, such as the working face or other possible sources of contamination, are collected by the leachate collection system and are disposed of via the City's sanitary sewer system for treatment.

# 4. Information Sources

The primary source of background information pertaining to site characteristics and the watersheds under considerations are:

- Topographic mapping and aerial photos of site and site vicinity;
- Sault Ste. Marie Flood Plain Mapping Report (M.M. Dillon, 1977);
- Root River Flood Plain Mapping Report (Walker Engineering, 1987);
- Design and Operations Report (M.M. Dillon Limited, 1990);
- Surface Water Drainage Assessment, Sault Ste. Marie Landfill (M.M. Dillon Limited, 1994);
- EA Terms of Reference (TSH, 2005);
- EA Phase 2 Study Report to-date (AECOM/Dillon/Genivar, 2010 and 2012);
- Sault Ste. Marie Municipal Landfill Site Monitoring Report (Dillon, 2011,2012 and 2013);
- Site Development and Operation Report, Sault Ste. Marie Municipal Landfill (AECOM, 2011, 2012 and 2013);
- Environment Canada Rainfall Intensity-Duration-Frequency (IDF) statistics (2013);
- Stormwater Management Guidelines – City of Sault Ste. Marie (R.V. Anderson 2014); and
- Water Survey of Canada Streamflow Data - WSC gauge 02CA002–Root River at Sault Ste. Marie (2014).

# 5. Existing-Proposed Conditions

## 5.1 General Features

The existing landfill site and proposed landfill expansion area are adjacent to Canon Creek to the North and East and the Root River to the South-East as illustrated in **Figure 2**.

The entire Root River basin is oriented in a northwest to southeast direction and drains approximately 210 $km^2$. It is the largest watershed within the jurisdiction of the Sault Ste. Marie Region Conservation Authority (SSMRCA). The Root River flows in a south to southeast direction from the Goulais River through the City of Sault Ste. Marie and the Rankin Indian Reserve to its outlet into the St. Mary's River near Little Lake George. There are four main tributaries within the basin, the Root River, the West Root River, Crystal Creek and Canon Creek.

Canon Creek is a major tributary of the Root River. It is oriented in a west to east direction and drains an area of approximately 23.3 $km^2$. In 2006, a small stretch of Canon Creek was realigned by moving the most southern section of the creek east away from the landfill to facilitate the extension of the existing landfill leachate collection system within the old creek bed. Canon Creek joins the Root River approximately 400 m north of the southern property boundary of the existing landfill site. Downstream of the confluence of Canon Creek and Root River is an old meander area that is to the south of the landfill, and is frequently inundated with water during high flow periods.

a) Physiography and Surficial Deposits

The physiography and soils of the watershed are a result of the most recent glaciation of Ontario, the Wisconsin.

The northern portion of the Root River basin (including a majority of the Canon Creek basin) is located within the Pre-Cambrian Shield. This area is characterized by hard, igneous intrusive bedrock with little or no overlying soils.

The southern portion of the basin consists of a series of ancient lake beaches and terraces left after the last period of glaciation. The soils in this portion of the basin consist of medium textured sands and gravels. These sands are underlain by glacial till, silts and clays.

In the area immediately upstream of the outlet of the Root River the soil types change to lacustrine clays and silts, and glacial till. These soils characterize the area south of the shoreline of a glacial melt water lake.

The soils in the area of the proposed landfill expansion consist of a deep layer of medium to coarse sands and gravels over silt or clay.

b) Land Use

The lands in the upstream reaches of the Root River basin are primarily forested areas. The area in close proximity to the landfill site is generally sparsely developed with aggregate extraction, low density residential, and some commercial uses. Downstream of the landfill site the sparsely developed land use pattern persists in proximity to the Root River extending to the Rankin Indian Reserve. For further information to the land uses in proximity to the landfill site please refer to the Land Use Impact Assessment Report.

c) Flow Characteristics

Water Survey of Canada (WSC) has maintained a gauging station (02CA002 – shown on **Figure 1**) on the Root River located near the western boundary of the Rankin Indian Reserve since 1971. Flow recorded at the gauge from this unregulated watershed can be regarded as representative of the entire study area.

Historical flows show that annual flood peaks typically occur in month of April but can also occur in the September – November period. The highest flow officially observed for the 1971 – 2013 period was 66.8m$^3$/s on April 22, 1992. However, the peak flow in 2013 has been estimated at 76.4m$^3$/s based on a recorded maximum daily flow of 59.7m$^3$/s on September 10, 2013 and a peaking factor of 1.28 (see **Appendix A**). Low flows can be expected in the July and August but can occur as late as September.

There is a lack of historical flooding within the reach that includes the proposed landfill expansion. This is largely due to the fact that there is only a limited amount of development between the proposed landfill site and the Rankin Indian Reserve.

d) Climate

Sault Ste. Marie is located in the western part of the Sudbury climatic region. The growing season is longer and the winters are warmer than most of northern Ontario.

Local climatic variations occur due to topography, altitude, and proximity to water. Typical characteristics of the region are summarized in **Table 1.**

**Table 1: Climatic Normals – Sault Ste. Marie**

| | |
|---|---|
| **Mean Annual Temperature ($^0$C)** | **4.3** |
| **Mean Daily Maximum Temperature ($^0$C)**<br>• **January**<br>• **July** | <br>-5.5<br>24 |
| **Mean Daily Minimum Temperature ($^0$C)**<br>• **January**<br>• **July** | <br>-15.5<br>11.3 |
| **Extreme Low Temperature ($^0$C)** | -38.9 |
| **Extreme High Temperature ($^0$C)** | 36.8 |
| **Mean Annual Precipitation (mm)** | 889 |
| **Mean Annual Snowfall (cm)** | 303 |

## 5.2 Proposed Landfill Site Conditions

A base map of the proposed landfill site, showing the drainage network, outlets and contributing subareas is provided in **Figure 2**. The proposed active landfill site (L1, L2, L3, L4) covers a total area of 50.4 ha (out of 145 ha owned by the City) and straddles the drainage divide between Canon Creek and the Root River watersheds. Surface drainage is provided by drainage ditches adjacent to the existing landfill: 12.2 ha of the northern half of the landfill site drains to Canon Creek while 38.2 ha drains to the Root River via both the meander loop south of the existing landfill footprint and the drainage ditch along the Fifth Line. Of the remaining drainage adjacent to the site that is not active landfill (E1, E2), 2.5 ha in the northeast will outlet to Canon Creek by a swale, to be constructed adjacent to the north perimeter of the SWM Pond, that conveys flow to the outfall swale at the SWM Pond.

There is currently no formal facility that provides SWM servicing for the existing landfill site, aside from the previously noted pit that collects water from the northeast portion of the site. Drainage ditches along the landfill perimeter intercept surface runoff and route stormwater from surrounding lands around the fill areas to one of the three outlets or the existing pit.

## 5.3 Hydrologic Modelling

Hydrologic modelling, using VO2, was undertaken to establish the peak flow rates at each drainage outlet from the site under proposed conditions. This is a HYMO based model and it use is consistent with the requirements of the City's SWM Guidelines. It is anticipated that the flows from the proposed conditions will not be significant enough to impact water levels or velocities in the receiving watercourses. The downstream reference points A and B (shown on **Figure 1**) were established to determine the potential influence on streamflow associated with the proposed landfill expansion.

In order to characterize the variation in flow rates, the analyses were carried out for two different design events, the 2-year and 100-year design storm. The former is representative of the more frequent rainfall events and appropriate for water quality considerations, while the latter is indicative of the more extreme events for which the flooding potential is evaluated.

The initial task in the hydrologic simulations involves the discretization of the site into units referred to as catchments. The discretization is normally governed by the specific locations where peak flow rates are required, the drainage network, site topography and uniformity of catchment characteristics.

The catchment delineation for the landfill site is shown on **Figure 2**. A total of six (6) catchments were used to define the proposed site conditions.

The input parameters employed in the hydrologic simulations, together with the methods used to derive the values, are consistent with the City's SWM Guidelines (Anderson 2014) and are presented as follows:

a) Design Storms

The design storm hyetographs for the 2 and 100-year return periods were developed using the intensity-duration-frequency (IDF) curves derived from rainfall recorded at the Sault Ste. Marie Airport meteorologic station. This station has been monitoring rainfall data in the area since 1962 and provides the most reliable data base for the analysis.

The temporal pattern of the rainfall for both design storms was arranged in accordance with the Keifer and Chu (Chicago) distribution with a storm duration of 12 hours. It is most appropriate for the examination of the attenuation effects of the storage elements. A computation time interval of 5 minutes was selected due to the short response time (time to peak) of the smaller subareas. The total rainfall depths are 40mm and 100mm for the 2-year and 100-year events respectively.

b) Runoff Curve Number (CN)

The runoff curve number (CN) is selected on the basis of soil type, land use and the antecedent moisture condition (AMC) of the soil. The antecedent moisture condition is an indicator of soil moisture based on the rainfall amount that occurred in the 5-day period prior to a storm event.

An average antecedent moisture condition (AMCII) is normally applied for the 2-year and 100-year design storms and the Timmins Storm. The land use for both basins was determined from available aerial photography and mappings of the existing landfill site. The soils were identified using the Blind River/Sault Ste. Marie soil map prepared by the Canada Department of Agriculture. The hydrologic classification was based on information contained in the United States Department of Agriculture Technical Release 55. The soil type throughout the site was determined to be Wendigo sand (hydrologic soil group A). Hence the runoff curve numbers within each subarea were weighted based on the percent of the subarea exhibiting a particular land use. The weighted CN values ranged from 51 to 70 for the existing site. The values assigned to each subarea are shown in **Table 2**.

c) Initial Abstraction (Ia)

The initial abstraction (Ia) is the interception, infiltration and surface storage of rainfall during the beginning of the storm before any runoff is produced. The primary factors which influence initial abstraction rates are the native soils, vegetative cover, and the extent of surface depressional storage. The initial abstraction was determined using guidelines provided in the VO2 reference manual:

| | |
|---|---|
| $CN \leq 70$ | $Ia = 0.075S$ |
| $70 < CN \leq 80$ | $Ia = 0.10S$ |
| $80 < CN \leq 90$ | $Ia = 0.15S$ |
| $CN > 90$ | $Ia = 0.2S$ |

Where S = soil storage (mm) and is given by the equation:

$$S = \frac{25400}{CN} - 254$$

The initial abstraction is used as a parameter in the Nash Unit Hydrograph model within VO2. The values assigned to each catchment are shown in **Table 2.**

d) Time to Peak ($T_p$)

The time of concentration of a watershed is the most difficult parameter to calculate when applying the Unit Hydrograph method, especially in areas with highly permeable soils. The time of concentration of a watershed comprises the initial overland and ditch flow times. The Soil Conservation Services (SCS) upland method was used to estimate the overland travel time component for each subarea. Ditch velocities were extracted from the OTTHYMO model contained in the Surface Water Assessment (Dillon 1994) and used to estimate channel travel times where applicable. Combining the overland and ditch travel times produced a time of concentration ($T_c$) for each subarea. The Time to Peak was determined to be the greater of 0.67Tc or the computational time step (5 min). The time to peak value for each catchment is shown in Table 2.

**Table 2: VO2 Model Parameters**

| **Catchment ID** | Area (ha) | CN | Ia (mm) | %Impervious | $T_p$ (hr) |
|---|---|---|---|---|---|
| **L1** | 9.7 | 69 | 8.6 | n/a | 0.192 |
| **L2** | 12.2 | 69 | 8.6 | n/a | 0.258 |
| **L3** | 18.7 | 69 | 8.6 | n/a | 0.235 |
| **L4** | 9.8 | 54 | 16.2 | 45 | n/a |
| **E1** | 11.4 | 54 | 16.2 | n/a | 0.083 |
| **E2** | 2.5 | 54 | 16.2 | n/a | 0.112 |

## 5.4 Proposed Condition - Peak Flows and Runoff Volumes

The results of the hydrologic analysis for the proposed conditions are summarized in **Table 3**. Predicted peak flow rates and runoff volumes are presented for each of the four drainage outlets shown on **Figure 2**. For further reference, the VO2 output for proposed conditions has been included in **Appendix A**.

**Table 3: VO2 Modelling Results –Proposed Conditions**

| **Flow Location** | **Landuse** | **Contributing Area (ha)** | **2-Year** | | **100-Year** | |
|---|---|---|---|---|---|---|
| | | | **Q ($m^3$/s)** | **R.V. ($m^3$)** | **Q ($m^3$/s)** | **R.V. ($m^3$)** |
| **L1 – SW Pond - to Root River (B)** | Proposed | 9.7 | 0.101 | 679 | 0.513 | 3831 |
| **L2 – NE Pond - to Canon Creek (A)** | Proposed | 12.2 | 0..106 | 854 | 0.787 | 4819 |
| **L3 – SE Pond - to Root River (B)** | Proposed | 18.7 | 0.173 | 1309 | 1.270 | 7368 |
| **L4 – S Pond - to Root River (B)** | Proposed | 9.8 | 0.980 | 2058 | 2.570 | 5880 |

In addition, a flood frequency analysis was conducted for the Root River and Canon Creek to establish 2-year and 100 year peak flow estimates for comparative purposes. Forty-three (43) years of observed flow data (1971-2013) obtained from WSC gauge 02CA002 – Root River at Sault Ste. Marie (shown on **Figure 1**) was used for the frequency analysis. Two missing peak flows were developed using daily flows and a peaking factor of 1.29 derived from available daily flow data for the entire period of record. Details are provided in **Appendix A**.

As recommended in the Flood Plain Management in Ontario, Technical Guidelines, as well as the Root River Study prepared by M.M. Dillon in 1987, the 3 Parameter Lognormal (3PLN) distribution (Maximum Likelihood) was selected as the preferred probability distribution. Results of the frequency analysis are presented in Table 4 and in **Appendix A**.

**Table 4: WSC Gauge 02CA002 Peak Flow Estimates 3 Parameter Lognormal Distribution (3PLN)**

| Return Period (Years) | Peak Flow Estimates ($m^3/s$) |
|---|---|
| **2** | 29 |
| **5** | 41 |
| **10** | 52 |
| **20** | 62 |
| **50** | 78 |
| **100** | 91 |

A Regional storm peak flow value of 159 $m^3/s$ for the Root River at the WSC streamflow gauge was extracted from the Root River Study prepared by M.M. Dillon in 1987.

As shown in **Figure 1**, the WSC gauge station is located approximately 6 km downstream of the subject site. In order to establish a comparison of 2-year and 100-year peak flow estimates at the landfill site, an area versus flow reduction equation was applied to the gauge values.

The flow transposition equation is as follows:

$$Q_2 = Q_1\left(\frac{A2}{A1}\right)^{0.75}$$ (MTO Drainage Manual Volume 3)

Where $Q_2$ = Desired peak flow estimate ($m^3/s$)

$Q_1$ = Flow estimate at gauge station ($m^3/s$)

$A_2$ = Area upstream of desired flow point ($km^2$)

$A_1$ = Area upstream of gauge station ($km^2$)

**Table 5** summarizes the transposed 2-year and 100-year peak flow estimates.

**Table 5: Peak Flow Estimates: Canon Creek - Root River**

| Flow Location | Contributing Drainage Area ($km^2$) | Peak Flow Estimates ($m^3/s$) | |
|---|---|---|---|
| | | 2-Year | 100-Year |
| **WSC Gauge 02CA002** | 108 | 29 | 91 |
| **at Landfill Outlet to Canon Creek (Flow Location A)** | 22 | 9 | 27 |
| **at Landfill Outlet to Root River (Flow Location B)** | 90 | 25 | 79 |

From the frequency analysis, a 2-year and 100-year peak flow comparison was conducted between the VO2 peak flows generated from the proposed landfill site and the receiving watercourses.The purpose of the comparison was to establish the relationship between the magnitude of the peak flow from the site and the magnitude of the peak flow in the receiving watercourse. Results are summarized in **Table 6**.

**Table 6: Peak Flow Comparison: Landfill vs Receiving Watercourse - Proposed Conditions**

| Design Storm | Peak Flow Rates ($m^3/s$) | | | | | |
|---|---|---|---|---|---|---|
| | Flow Location B (Outlet to Canon Creek) | | | Flow Location C (Outlet to Root River) | | |
| | Proposed Landfill Site | Canon Creek | % of Flow from Landfill Site | Proposed Landfill Site | Root River | % of Flow from Landfill Site |
| **2-Year** | 0.106 | 9 | 1% | 1.3 | 27 | 5% |
| **100-Year** | 0.787 | 25 | 3% | 4.6 | 79 | 6% |

The total drainage area upstream of existing landfill outlets to Canon Creek and Root River are 22 $km^2$ and 90 $km^2$ respectively. The total surface drainage area associated with the proposed landfill site is approximately 54.5 ha that includes both the proposed landfill footprint and adjacent drainage areas. This represents approximately 0.5% of the entire drainage area.

As shown on **Table 6**, the contribution of proposed site runoff to Canon Creek and the Root River is minimal in terms of peak flows: at flow location A, the landfill site (L2) generates a 2-year and 100-year storm flow of 0.106 and 0.787 $m^3/s$, representing only 1% and 3%, respectively, of the total flow in Canon Creek. Similarly, at flow location B (L1, L3, L4), the runoff from the landfill site generates a 2-year and 100-year storm flow of 1.3 and 4.6 $m^3/s$. These peak flows represent only 5% and 6%, respectively, of the Root River flow at this location.

More importantly, if you consider the timing of the peak flows (Tp) between the larger watercourse drainage areas of the receiving watercourses and the smaller landfill site drainage area, the impact of landfill site runoff on peak watercourse flows is negligible. Times of concentration (Tc=>travel time) on Canon Creek and the Root River have been estimated at 5 hours and 7 hours, respectively, based on channel lengths (18km; 35km) and channel slopes (0.8%; 0.6%) derived from Ontario Flow Assessment Tool III (MNR 2014) and estimated velocities of 1m/s. This is adjusted to Tp by a factor of 0.67 so that the Tp of Canon Creek and the Root River are 3.5 hours and 4.7 hours, respectively. Tp for the landfill site is 0.2 hours. Since the timing of the peak flows from the site and the receiving watercourse do not coincide by a significant margin, the unregulated peak flows from the landfill site will not impact peak flows on the receiving watercourses.

## 5.5 Water Quality

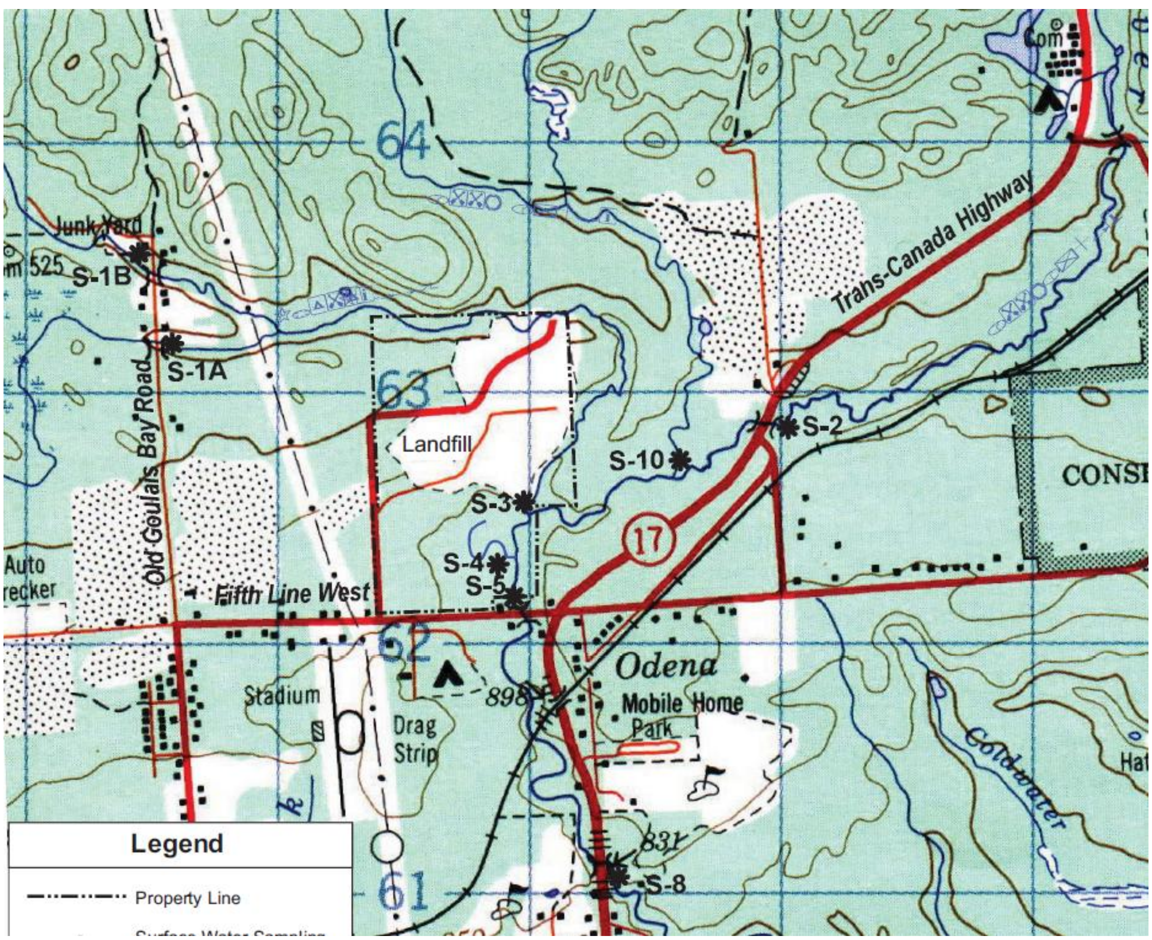
A monitoring program has been in place for the existing landfill site as directed by MOE. The surface water monitoring component includes the collection of water samples at sampling points along Canon Creek and the Root River. Five surface water sampling locations (stations S-1B, S-2, S-3, S-4 and S-5, shown on **Figure 3** ) are being sampled annually. Summary results for selected parameters, averaged for the summer months, were extracted from *Sault Ste. Marie Municipal Landfill Site Monitoring Report 2012 - Final Report (2013 Dillon)* and are summarised in **Table 7.** They provide an indication of surface water quality baseline conditions before expansion and will be used as a long term indicator of change in water quality in relation to the landfill site.

**Table 7: Surface Water Quality - 2012**

| Location | DO | Total P | Lead | Chloride |
|---|---|---|---|---|
| **S-1B** | 8.0 | 45 | <1 | 0.75 |
| **S-2** | 8.5 | 50 | <1 | 42 |
| **S-3** | 8.7 | 52 | <1 | 1.6 |
| **S-4** | 8.0 | 45 | <1 | 2.7 |
| **S-5** | 8.7 | 42 | <1 | 9.5 |

The need for water quality impact mitigation due to the effect of the internal roadway system, the administrative building, public drop-off, recycling centre and composting area will be addressed by the design of SWM Ponds, with forebays. These SWMP will reduce Total Suspended Solids (TSS) loadings, by 80%, to the receiving watercourses. Preliminary conceptual designs have been developed and are reported in more detail below. These single stage SWMPs will not only reduce TSS loadings but also provide for emergency leachate/spill containment with the provision of an emergency shutoff valve at the outlet and a clay liner to prevent infiltration to groundwater.

**Figure 3: Surface Water Quality Monitoring Stations**



# 6. Surface Water Net Effects

The existing landfill site and proposed landfill expansion are situated adjacent to the Canon Creek to the North and East and the Root River to the South-East as illustrated in **Figure 1** and **Figure 2**. The soils in the area of the proposed landfill expansion consist of a deep layer of relatively permeable medium to coarse sands and gravels over silt or clay.

Potable water supply in adjacent built-up areas to the south and southwest is from the Municipal supply and distribution system while potable water for the rural areas to the north, east and southeast is from private wells.

The potential surface water effects, mitigation/compensation measures, and net effects are summarized in **Table 8** and described in further detail in the sections below.

**Table 8: Net Effects**

| Potential Effect | Mitigation | Net Effect |
|---|---|---|
| **Water quality impact from leachate or spills** | Storage in lined SWM facility | none |
| **Water quality impact from TSS** | TSS Removal in SWM Facility | minimal |
| **Water quality thermal impact** | Bottom draw; Shading | reduced |
| **Water quantity impact** | Free Flow from site | none |

## 6.1 Potential Effects on Surface Water

Potential surface water impacts from the landfill are as follows.

From a water quality perspective, there are potential impacts due to accidental leachate seeps to the surface and/or increases in Total Suspended Solids (TSS) concentration due to runoff from the internal operations on the paved access roadways or site erosion. As well, there is a potential for thermal impact from the permanent pool feature of the SWMPs and the coldwater fisheries status of the Root River.

From a water quantity perspective, there are negligible impacts since peak flows from the site are significantly smaller than those of the receiving watercourse and the peaks do not coincide.

## 6.2 Mitigation, Compensation and/or Contingency Measures

Surface water impact mitigation will be as follows:

Water quality impacts would be mitigated by a single stage SWMP to reduce TSS loading and provide for emergency leachate/spill containment. SWMP outflow would be through open channel to the nearest receiving watercourse. The outflow structure design would have bottom draw characteristics and landscaping should encourage shading of the SWMPs. Conceptual Plans are provided in **Appendix A.**

There is no mitigation proposed for water quantity as the impact is insignificant.

On site stormwater management (SWM) will be achieved through the existing/proposed system of ditches, culverts, and SWM ponds that have been designed to mitigate the impacts of stormwater runoff on water quality before discharge to Canon Creek or the Root River. The SWM criteria, as identified by the MOE in Ontario Regulation 232/98 and related Landfill Standards Guidelines (1998), include ditches with a 1:25 year capacity and runoff treatment for 80% TSS removal.

The four new SWM ponds described in Section 7 will also be designed with emergency flow control systems at their outlet, as a contingency. The SWM Pond can act as an emergency response cell where runoff can be stored in case of surface water contamination by leachate or onsite spills. Emergency response could be assisted by consideration of a program of regular inflow monitoring of indicator parameters (possibly including Oil and Grease, Conductivity, pH and TDS) to trigger a manual shutdown response using either a control valve or gate. The ponds will be lined and designed to retain the complete runoff from the 1:100 year rainfall until appropriate treatment can be applied. The contaminated runoff will either be treated and discharged to the receiving watercourse or pumped and hauled for treatment elsewhere.

# 7. Proposed Surface Water Management Plan

## 7.1 Drainage

The proposed site will be drained by ditches adjacent to the internal roadway system. Their locations are identified in **Figure 2** with a typical ditch being V-shaped with a maximum 2:1 side-slope and a minimum depth of 0.3m (includes 0.1m freeboard) to convey the 1:25 Year flow .

## 7.2 Stormwater Management Ponds

Four (4) SWM Ponds are proposed, to mitigate runoff impacts, as illustrated in **Figure 2**. One in the southwest for landfill catchment L1; one in the northeast for landfill catchment L2; one in the southeast for landfill catchment L3 and a final one in the southeast for catchment L4 which represents the public drop-off, administration building, recycling centre, compost pad and adjacent paved areas.

SWM Ponds for catchments L1, L2 and L3 will all have sufficient storage capacity to accommodate runoff from the 1:100 Year storm event for operation under emergency leachate spill conditions. Such emergency control is not required for drainage from catchment L4.

As well, all four (4) SWM Ponds will be designed to operate as water quality control facilities as identified in the City's SWM Guidelines (RV Anderson 2014) and will achieve MOE Level 1 criteria (80%TSS removal). The SWMPs will be lined to eliminate infiltration since the landfill site is in an area of high groundwater recharge and runoff has the potential to be contaminated.

There will be no quantity control function. The proposed SWM Pond characteristics at the four locations are identified in more detail in **Appendix B**.

Any effluent monitoring requirements would be confirmed at the time of MOECC ECA approval and would likely include TSS. Influent monitoring could include TDS or alternative parameters that would indicate leachate seepage or upstream spills; although this might be, in its initial stages, a simple visual monitoring program.

# 8. Surface Water Approvals Required for the Undertaking

As part of the implementation plan for surface water impact mitigation, the following permits and approvals would be required:

- Development, Interference with Wetlands and Alternations to Shorelines and Watercourses permit from the local Conservation Authority; and
- A Ministry of Environment and Climate Change (MOECC) Environmental Compliance Approval (ECA) for the four SWM Ponds and related conveyance systems.

# Appendix A

Single Station Frequency Analysis (SSFA)
Hydrologic Model Output – Proposed Conditions

| | | PEAK | | | DAILY | | DAILY | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ID | Year | HH:MM | MM--DD | PEAK | DAILY | Daily MM--DD | DAILY | Daily MM--DD | Peaking Factor | Peak Estimate |
| 02CA002 | 1971 | 6:43 | 12--11 | 24.2 | 23.6 | 04--20 | 17.9 | 12--11 | 1.35 | |
| 02CA002 | 1972 | 1:20 | 05--03 | 28 | 24.8 | 05--03 | | | 1.13 | |
| 02CA002 | 1973 | 2:06 | 11--22 | 19.9 | 16.2 | 03--12 | 15.5 | 11--22 | 1.28 | |
| 02CA002 | 1974 | 5:50 | 04--22 | 20.3 | 19.3 | 04--22 | | | 1.05 | |
| 02CA002 | 1975 | 12:07 | 05--01 | 42.2 | 35.7 | 05--01 | | | 1.18 | |
| 02CA002 | 1976 | | | 26.6 | 20.8 | 04--17 | | | | 26.6 |
| 02CA002 | 1977 | 22:15 | 04--18 | 29.4 | 23.4 | 04--19 | | | 1.26 | |
| 02CA002 | 1978 | 19:34 | 10--03 | 33.7 | 16.9 | 10--04 | | | 1.99 | |
| 02CA002 | 1979 | 20:30 | 04--25 | 55.7 | 42.2 | 04--26 | | | 1.32 | |
| 02CA002 | 1980 | 6:53 | 04--09 | 33.8 | 31 | 04--09 | | | 1.09 | |
| 02CA002 | 1981 | 22:14 | 04--04 | 40.6 | 31.8 | 04--04 | | | 1.28 | |
| 02CA002 | 1982 | 7:00 | 04--26 | 31.7 | 29.8 | 04--26 | | | 1.06 | |
| 02CA002 | 1983 | 18:02 | 04--14 | 56.7 | 27.7 | 04--14 | | | 2.05 | |
| 02CA002 | 1984 | 7:20 | 09--13 | 31.3 | 20.3 | 09--13 | | | 1.54 | |
| 02CA002 | 1985 | 22:19 | 04--22 | 53.9 | 43.2 | 04--23 | | | 1.25 | |
| 02CA002 | 1986 | 6:20 | 04--08 | 19.5 | 18.2 | 04--08 | | | 1.07 | |
| 02CA002 | 1987 | 4:11 | 10--18 | 14.7 | 12 | 10--18 | | | 1.23 | |
| 02CA002 | 1988 | 17:04 | 04--06 | 39.9 | 32.9 | 04--06 | | | 1.21 | |
| 02CA002 | 1989 | 0:59 | 04--27 | 20.2 | 17.8 | 04--27 | | | 1.13 | |
| 02CA002 | 1990 | 23:37 | 04--25 | 25 | 24.5 | 03--16 | 20.7 | 04--25 | 1.21 | |
| 02CA002 | 1991 | 1:07 | 04--08 | 31 | 26.1 | 04--08 | | | 1.19 | |
| 02CA002 | 1992 | 4:36 | 04--22 | 66.8 | 47.4 | 04--22 | | | 1.41 | |
| 02CA002 | 1993 | 17:43 | 04--09 | 26.4 | 20.6 | 04--09 | | | 1.28 | |
| 02CA002 | 1994 | 1:01 | 04--25 | 23.9 | 19.2 | 04--27 | | | 1.24 | |
| 02CA002 | 1995 | 11:17 | 08--31 | 27 | 16.7 | 08--31 | | | 1.62 | |
| 02CA002 | 1996 | 0:19 | 04--22 | 22.9 | 21.4 | 04--22 | | | 1.07 | |
| 02CA002 | 1997 | 22:00 | 04--06 | 27.2 | 22.2 | 04--07 | | | 1.23 | |
| 02CA002 | 1998 | 6:30 | 03--30 | 29.8 | 25.8 | 03--30 | | | 1.16 | |
| 02CA002 | 1999 | 18:15 | 04--06 | 35.5 | 25.2 | 04--08 | | | 1.41 | |
| 02CA002 | 2000 | 0:40 | 03--26 | 14.9 | 13 | 03--25 | | | 1.15 | |
| 02CA002 | 2001 | 12:10 | 10--14 | 42.6 | 32.9 | 04--12 | 28.3 | 10--14 | 1.51 | |
| 02CA002 | 2002 | 21:45 | 04--16 | 51.9 | 42.1 | 04--17 | | | 1.23 | |
| 02CA002 | 2003 | 17:40 | 04--20 | 45.1 | 34.4 | 04--20 | | | 1.31 | |
| 02CA002 | 2004 | 16:25 | 04--19 | 20.8 | 18.7 | 04--19 | | | 1.11 | |
| 02CA002 | 2005 | 5:20 | 04--07 | 23 | 21.2 | 04--07 | | | 1.08 | |
| 02CA002 | 2006 | 21:45 | 04--12 | 20.1 | 15.9 | 04--12 | | | 1.26 | |
| 02CA002 | 2007 | 5:35 | 11--06 | 17 | 14 | 11--06 | | | 1.21 | |
| 02CA002 | 2008 | 21:50 | 04--17 | 26.4 | 22.6 | 04--20 | | | 1.17 | |
| 02CA002 | 2009 | 2:00 | 04--25 | 17 | 15.3 | 04--25 | | | 1.11 | |
| 02CA002 | 2010 | 10:15 | 09--24 | 53 | 34 | 09--24 | | | 1.56 | |
| 02CA002 | 2011 | 3:30 | 04--28 | 28.3 | 20.9 | 04--28 | | | 1.35 | |
| 02CA002 | 2012 | 1:00 | 03--19 | 21.6 | 19.3 | 03--18 | | | 1.12 | |
| 02CA002 | 2013 | | | 76.4 | 59.7 | 09--10 | | | | 76.4 |
| | | | | | | | | PEAKING FACTOR | 1.28 | |

***HYFRANPLUS***


**SSM - Landfill - WSC - Root River**

3-parameter lognormal (Maximum Likelihood)

**Results of the fitting**

Number of observations : 43

**Parameters**

| | |
|---|---|
| m | 10.207561 |
| mu | 2.905805 |
| sigma | 0.635895 |

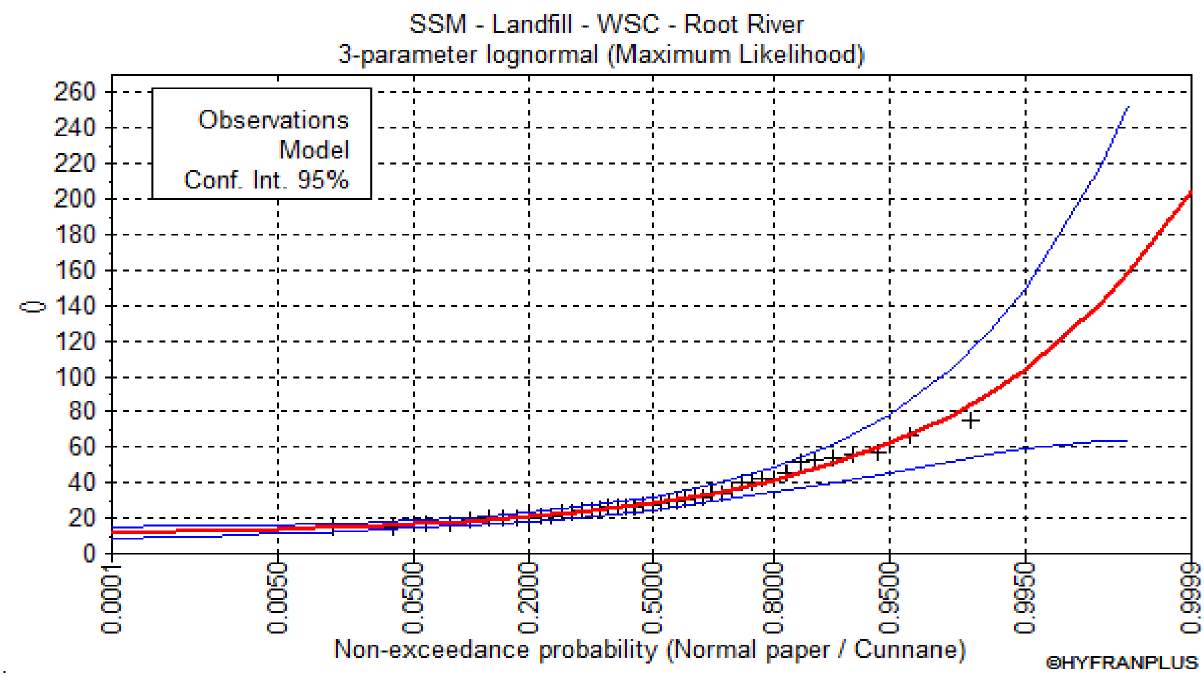
**Quantiles**

q = F(X) : non-exceedance probability
T = 1/(1-q)

| T | q | XT | Standard deviation | Confidence interval (95%) |
|---|---|---|---|---|
| 10000.0 | 0.9999 | 205 | 73.0 | N/D |
| 2000.0 | 0.9995 | 158 | 48.2 | 64.0 - 253 |
| 1000.0 | 0.9990 | 141 | 39.4 | 63.3 - 218 |
| 200.0 | 0.9950 | 104 | 23.2 | 58.8 - 150 |
| 100.0 | 0.9900 | 90.5 | 17.8 | 55.7 - 125 |
| 50.0 | 0.9800 | 77.7 | 13.2 | 51.9 - 104 |
| 20.0 | 0.9500 | 62.2 | 8.34 | 45.9 - 78.6 |
| 10.0 | 0.9000 | 51.5 | 5.56 | 40.6 - 62.4 |
| 5.0 | 0.8000 | 41.4 | 3.52 | 34.5 - 48.3 |
| 3.0 | 0.6667 | 34.2 | 2.48 | 29.4 - 39.1 |
| 2.0 | 0.5000 | 28.5 | 1.87 | 24.8 - 32.2 |
| 1.4286 | 0.3000 | 23.3 | 1.43 | 20.5 - 26.1 |
| 1.2500 | 0.2000 | 20.9 | 1.24 | 18.5 - 23.3 |
| 1.1111 | 0.1000 | 18.3 | 1.06 | 16.2 - 20.4 |
| 1.0526 | 0.0500 | 16.6 | 1.01 | 14.7 - 18.6 |
| 1.0204 | 0.0200 | 15.2 | 1.05 | 13.1 - 17.2 |
| 1.0101 | 0.0100 | 14.4 | 1.13 | 12.2 - 16.6 |
| 1.0050 | 0.0050 | 13.8 | 1.22 | 11.4 - 16.2 |
| 1.0010 | 0.0010 | 12.8 | 1.44 | 9.95 - 15.6 |
| 1.0005 | 0.0005 | 12.5 | 1.52 | 9.47 - 15.5 |
| 1.0001 | 0.0001 | 11.9 | 1.70 | 8.59 - 15.3 |

*HYFRANPLUS*


**SSM - Landfill - WSC - Root River**



**STANDHYD** Used to simulate design hydrographs from urban watersheds. With this command, the model uses two parallel standard instantaneous unit hydrographs to convolute the effective rainfall intensity over the pervious and impervious surfaces. The losses over the pervious area can be calculated by one of the three methods: i) Horton's soil infiltration equation; ii) SCS modified CN procedure; or iii) Proportional Loss Coefficient. A baseflow can be added to the total simulated hydrograph. To obtain adequate results, the command should be applied to areas with impervious ratios larger than 20% (for smaller impervious ratios the watershed can be broken down into urban and rural basins).

**NASHYD** Used to simulate design hydrographs with the Nash instantaneous unit hydrograph. This hydrograph is made of a cascade of 'N' linear reservoirs. The command is mainly used for rural areas but can also be used for very large urban watersheds and to simulate the effects of infiltration /inflow in sanitary sewers. Rainfall losses can be computed by a SCS modified CN procedure or Proportional Loss Coefficient.

**Statistics**

**Rainfall intensity (mm $hr^{-1}$)**

| Duration | 5-min | 10-min | 15-min | 30-min | 1-hr | 2-hr | 6-hr | 12-hr | 24-hr |
|---|---|---|---|---|---|---|---|---|---|
| 2-yr | 109.4 | 67.5 | 50.9 | 31.4 | 19.4 | 12.0 | 5.6 | 3.4 | 2.1 |
| 5-yr | 148.5 | 91.7 | 69.2 | 42.7 | 26.4 | 16.3 | 7.6 | 4.7 | 2.9 |
| 10-yr | 174.9 | 108.0 | 81.5 | 50.3 | 31.1 | 19.2 | 9.0 | 5.5 | 3.4 |
| 25-yr | 208.1 | 128.5 | 97.0 | 59.9 | 37.0 | 22.9 | 10.7 | 6.6 | 4.1 |
| 50-yr | 232.3 | 143.5 | 108.2 | 66.9 | 41.3 | 25.5 | 11.9 | 7.3 | 4.5 |
| 100-yr | 255.9 | 158.1 | 119.2 | 73.7 | 45.5 | 28.1 | 13.1 | 8.1 | 5.0 |

---

****************************
** SIMULATION NUMBER:   1 **
****************************

## 2 YEAR EVENT – SSM Landfill – Proposed Conditions

```
--------------------
| CHICAGO STORM    |     IDF curve parameters: A= 320.010
| Ptotal= 40.73 mm |                           B=   0.001
--------------------                           C=   0.691
                        used in:   INTENSITY =  A / (t + B)^C

                        Duration of storm  = 12.00 hrs
                        Storm time step    =  5.00 min
                        Time to peak ratio =  0.33
```

| TIME hrs | RAIN mm/hr | TIME hrs | RAIN mm/hr | TIME hrs | RAIN mm/hr | TIME hrs | RAIN mm/hr |
|---|---|---|---|---|---|---|---|
| 0.08 | 1.07 | 3.08 | 2.93 | 6.08 | 2.65 | 9.08 | 1.43 |
| 0.17 | 1.08 | 3.17 | 3.14 | 6.17 | 2.58 | 9.17 | 1.42 |
| 0.25 | 1.10 | 3.25 | 3.38 | 6.25 | 2.51 | 9.25 | 1.40 |
| 0.33 | 1.12 | 3.33 | 3.67 | 6.33 | 2.45 | 9.33 | 1.39 |
| 0.42 | 1.13 | 3.42 | 4.04 | 6.42 | 2.39 | 9.42 | 1.37 |
| 0.50 | 1.15 | 3.50 | 4.50 | 6.50 | 2.33 | 9.50 | 1.36 |
| 0.58 | 1.17 | 3.58 | 5.13 | 6.58 | 2.28 | 9.58 | 1.34 |
| 0.67 | 1.19 | 3.67 | 6.03 | 6.67 | 2.23 | 9.67 | 1.33 |
| 0.75 | 1.21 | 3.75 | 7.45 | 6.75 | 2.19 | 9.75 | 1.32 |
| 0.83 | 1.24 | 3.83 | 10.16 | 6.83 | 2.14 | 9.83 | 1.30 |
| 0.92 | 1.26 | 3.92 | 18.76 | 6.92 | 2.10 | 9.92 | 1.29 |
| 1.00 | 1.28 | 4.00 | 105.22 | 7.00 | 2.06 | 10.00 | 1.28 |
| 1.08 | 1.31 | 4.08 | 22.97 | 7.08 | 2.02 | 10.08 | 1.27 |
| 1.17 | 1.33 | 4.17 | 14.56 | 7.17 | 1.98 | 10.17 | 1.25 |
| 1.25 | 1.36 | 4.25 | 11.14 | 7.25 | 1.95 | 10.25 | 1.24 |
| 1.33 | 1.39 | 4.33 | 9.20 | 7.33 | 1.92 | 10.33 | 1.23 |
| 1.42 | 1.42 | 4.42 | 7.92 | 7.42 | 1.88 | 10.42 | 1.22 |
| 1.50 | 1.46 | 4.50 | 7.00 | 7.50 | 1.85 | 10.50 | 1.21 |
| 1.58 | 1.49 | 4.58 | 6.31 | 7.58 | 1.82 | 10.58 | 1.20 |
| 1.67 | 1.53 | 4.67 | 5.76 | 7.67 | 1.79 | 10.67 | 1.19 |
| 1.75 | 1.57 | 4.75 | 5.32 | 7.75 | 1.77 | 10.75 | 1.18 |
| 1.83 | 1.61 | 4.83 | 4.95 | 7.83 | 1.74 | 10.83 | 1.17 |
| 1.92 | 1.65 | 4.92 | 4.64 | 7.92 | 1.71 | 10.92 | 1.16 |
| 2.00 | 1.70 | 5.00 | 4.37 | 8.00 | 1.69 | 11.00 | 1.15 |
| 2.08 | 1.75 | 5.08 | 4.14 | 8.08 | 1.67 | 11.08 | 1.14 |
| 2.17 | 1.81 | 5.17 | 3.94 | 8.17 | 1.64 | 11.17 | 1.13 |
| 2.25 | 1.87 | 5.25 | 3.76 | 8.25 | 1.62 | 11.25 | 1.12 |
| 2.33 | 1.93 | 5.33 | 3.59 | 8.33 | 1.60 | 11.33 | 1.11 |
| 2.42 | 2.00 | 5.42 | 3.45 | 8.42 | 1.58 | 11.42 | 1.10 |
| 2.50 | 2.08 | 5.50 | 3.32 | 8.50 | 1.56 | 11.50 | 1.10 |
| 2.58 | 2.16 | 5.58 | 3.19 | 8.58 | 1.54 | 11.58 | 1.09 |
| 2.67 | 2.26 | 5.67 | 3.08 | 8.67 | 1.52 | 11.67 | 1.08 |

```
               2.75    2.36 |  5.75    2.98 |  8.75    1.50 | 11.75    1.07
               2.83    2.48 |  5.83    2.89 |  8.83    1.48 | 11.83    1.06
               2.92    2.61 |  5.92    2.80 |  8.92    1.47 | 11.92    1.06
               3.00    2.76 |  6.00    2.72 |  9.00    1.45 | 12.00    1.05


-------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0005) |   Area    (ha)=  18.70   Curve Number   (CN)= 69.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   8.60   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.23

     Unit Hyd Qpeak  (cms)=   3.039

     PEAK FLOW       (cms)=   0.173 (i)
     TIME TO PEAK    (hrs)=   4.250
     RUNOFF VOLUME    (mm)=   7.052
     TOTAL RAINFALL   (mm)=  40.731
     RUNOFF COEFFICIENT   =   0.173

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0001) |   Area    (ha)=  11.40   Curve Number   (CN)= 54.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=  16.20   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.08

     Unit Hyd Qpeak  (cms)=   5.246

     PEAK FLOW       (cms)=   0.022 (i)
     TIME TO PEAK    (hrs)=   4.167
     RUNOFF VOLUME    (mm)=   2.373
     TOTAL RAINFALL   (mm)=  40.731
     RUNOFF COEFFICIENT   =   0.058

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0003) |   Area    (ha)=   9.70   Curve Number   (CN)= 69.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   8.60   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.19

     Unit Hyd Qpeak  (cms)=   1.930

     PEAK FLOW       (cms)=   0.101 (i)
     TIME TO PEAK    (hrs)=   4.167
     RUNOFF VOLUME    (mm)=   7.043
     TOTAL RAINFALL   (mm)=  40.731
     RUNOFF COEFFICIENT   =   0.173
```

```
     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------

--------------------
| ADD HYD   (0006) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0001):    11.40   0.022     4.17     2.37
        + ID2= 2 (0003):     9.70   0.101     4.17     7.04
          ==================================================
          ID = 3 (0006):    21.10   0.123     4.17     4.52

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0002) |   Area    (ha)=   2.50   Curve Number   (CN)= 54.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=  16.20   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.11

     Unit Hyd Qpeak  (cms)=   0.853

     PEAK FLOW       (cms)=   0.005 (i)
     TIME TO PEAK    (hrs)=   4.250
     RUNOFF VOLUME    (mm)=   2.455
     TOTAL RAINFALL   (mm)=  40.731
     RUNOFF COEFFICIENT   =   0.060

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0004) |   Area    (ha)=  12.20   Curve Number   (CN)= 69.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   8.60   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.26

     Unit Hyd Qpeak  (cms)=   1.806

     PEAK FLOW       (cms)=   0.106 (i)
     TIME TO PEAK    (hrs)=   4.333
     RUNOFF VOLUME    (mm)=   7.054
     TOTAL RAINFALL   (mm)=  40.731
     RUNOFF COEFFICIENT   =   0.173

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------

--------------------
| ADD HYD   (0007) |
```

```
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------          (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0002):      2.50   0.005     4.25     2.45
        + ID2= 2 (0004):     12.20   0.106     4.33     7.05
          ==================================================
          ID = 3 (0007):     14.70   0.110     4.33     6.27

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD  (0008) |   Area    (ha)=   9.80
|ID= 1 DT= 5.0 min |   Total Imp(%)=  47.00   Dir. Conn.(%)=  47.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       4.61         5.19
     Dep. Storage     (mm)=       1.00        10.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     255.60        40.00
     Mannings n           =      0.013        0.250

     Max.Eff.Inten.(mm/hr)=     105.22         1.70
                over (min)        5.00        45.00
     Storage Coeff.  (min)=       4.40 (ii)   40.39 (ii)
     Unit Hyd. Tpeak (min)=       5.00        45.00
     Unit Hyd. peak  (cms)=       0.23         0.03
                                                           *TOTALS*
     PEAK FLOW       (cms)=       0.98         0.01          0.980 (iii)
     TIME TO PEAK    (hrs)=       4.00         4.92           4.00
     RUNOFF VOLUME    (mm)=      39.73         3.96          20.77
     TOTAL RAINFALL   (mm)=      40.73        40.73          40.73
     RUNOFF COEFFICIENT   =       0.98         0.10           0.51

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  55.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
```

```
 ****************************
  ** SIMULATION NUMBER:   2 **
  ****************************
```

## 100 YEAR EVENT – SSM Landfill – Proposed Conditions

```
--------------------
| CHICAGO STORM    |     IDF curve parameters: A= 705.090
| Ptotal= 98.40 mm |                           B=   0.001
--------------------                           C=   0.677
                         used in:   INTENSITY =  A / (t + B)^C

                         Duration of storm  = 12.00 hrs
                         Storm time step    =  5.00 min
                         Time to peak ratio =  0.33
```

| TIME hrs | RAIN mm/hr | TIME hrs | RAIN mm/hr | TIME hrs | RAIN mm/hr | TIME hrs | RAIN mm/hr |
|---|---|---|---|---|---|---|---|
| 0.08 | 2.69 | 3.08 | 7.25 | 6.08 | 6.56 | 9.08 | 3.60 |
| 0.17 | 2.73 | 3.17 | 7.75 | 6.17 | 6.39 | 9.17 | 3.56 |
| 0.25 | 2.77 | 3.25 | 8.33 | 6.25 | 6.23 | 9.25 | 3.52 |
| 0.33 | 2.81 | 3.33 | 9.04 | 6.33 | 6.08 | 9.33 | 3.48 |
| 0.42 | 2.86 | 3.42 | 9.92 | 6.42 | 5.94 | 9.42 | 3.44 |
| 0.50 | 2.91 | 3.50 | 11.04 | 6.50 | 5.80 | 9.50 | 3.41 |
| 0.58 | 2.95 | 3.58 | 12.55 | 6.58 | 5.68 | 9.58 | 3.37 |
| 0.67 | 3.00 | 3.67 | 14.70 | 6.67 | 5.55 | 9.67 | 3.34 |
| 0.75 | 3.06 | 3.75 | 18.09 | 6.75 | 5.44 | 9.75 | 3.31 |
| 0.83 | 3.11 | 3.83 | 24.50 | 6.83 | 5.33 | 9.83 | 3.28 |
| 0.92 | 3.17 | 3.92 | 44.64 | 6.92 | 5.23 | 9.92 | 3.24 |
| 1.00 | 3.23 | 4.00 | 237.13 | 7.00 | 5.13 | 10.00 | 3.21 |
| 1.08 | 3.29 | 4.08 | 54.47 | 7.08 | 5.04 | 10.08 | 3.18 |
| 1.17 | 3.35 | 4.17 | 34.86 | 7.17 | 4.95 | 10.17 | 3.16 |
| 1.25 | 3.42 | 4.25 | 26.81 | 7.25 | 4.86 | 10.25 | 3.13 |
| 1.33 | 3.50 | 4.33 | 22.22 | 7.33 | 4.78 | 10.33 | 3.10 |
| 1.42 | 3.57 | 4.42 | 19.19 | 7.42 | 4.70 | 10.42 | 3.07 |
| 1.50 | 3.65 | 4.50 | 17.02 | 7.50 | 4.62 | 10.50 | 3.05 |
| 1.58 | 3.74 | 4.58 | 15.36 | 7.58 | 4.55 | 10.58 | 3.02 |
| 1.67 | 3.83 | 4.67 | 14.06 | 7.67 | 4.48 | 10.67 | 2.99 |
| 1.75 | 3.92 | 4.75 | 13.00 | 7.75 | 4.41 | 10.75 | 2.97 |
| 1.83 | 4.03 | 4.83 | 12.12 | 7.83 | 4.35 | 10.83 | 2.94 |
| 1.92 | 4.14 | 4.92 | 11.37 | 7.92 | 4.29 | 10.92 | 2.92 |
| 2.00 | 4.25 | 5.00 | 10.73 | 8.00 | 4.23 | 11.00 | 2.90 |
| 2.08 | 4.38 | 5.08 | 10.17 | 8.08 | 4.17 | 11.08 | 2.87 |
| 2.17 | 4.51 | 5.17 | 9.68 | 8.17 | 4.11 | 11.17 | 2.85 |
| 2.25 | 4.66 | 5.25 | 9.24 | 8.25 | 4.06 | 11.25 | 2.83 |
| 2.33 | 4.82 | 5.33 | 8.85 | 8.33 | 4.00 | 11.33 | 2.81 |
| 2.42 | 4.99 | 5.42 | 8.50 | 8.42 | 3.95 | 11.42 | 2.79 |
| 2.50 | 5.18 | 5.50 | 8.18 | 8.50 | 3.90 | 11.50 | 2.76 |
| 2.58 | 5.38 | 5.58 | 7.89 | 8.58 | 3.86 | 11.58 | 2.74 |
| 2.67 | 5.61 | 5.67 | 7.62 | 8.67 | 3.81 | 11.67 | 2.72 |
| 2.75 | 5.86 | 5.75 | 7.37 | 8.75 | 3.76 | 11.75 | 2.70 |
| 2.83 | 6.15 | 5.83 | 7.15 | 8.83 | 3.72 | 11.83 | 2.68 |

```
                2.92    6.47 |  5.92    6.94 |  8.92    3.68 | 11.92    2.67
                3.00    6.83 |  6.00    6.74 |  9.00    3.64 | 12.00    2.65


----------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0005) |   Area    (ha)=  18.70   Curve Number   (CN)= 69.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   8.60   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.23

     Unit Hyd Qpeak  (cms)=   3.039

     PEAK FLOW       (cms)=   1.271 (i)
     TIME TO PEAK    (hrs)=   4.250
     RUNOFF VOLUME    (mm)=  39.508
     TOTAL RAINFALL   (mm)=  98.403
     RUNOFF COEFFICIENT   =   0.401

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

----------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0001) |   Area    (ha)=  11.40   Curve Number   (CN)= 54.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=  16.20   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.08

     Unit Hyd Qpeak  (cms)=   5.246

     PEAK FLOW       (cms)=   0.680 (i)
     TIME TO PEAK    (hrs)=   4.000
     RUNOFF VOLUME    (mm)=  21.501
     TOTAL RAINFALL   (mm)=  98.403
     RUNOFF COEFFICIENT   =   0.219

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

----------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0003) |   Area    (ha)=   9.70   Curve Number   (CN)= 69.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   8.60   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.19

     Unit Hyd Qpeak  (cms)=   1.930

     PEAK FLOW       (cms)=   0.760 (i)
     TIME TO PEAK    (hrs)=   4.167
     RUNOFF VOLUME    (mm)=  39.460
     TOTAL RAINFALL   (mm)=  98.403
     RUNOFF COEFFICIENT   =   0.401

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.
```

```
--------------------------------------------------------------------------------

 --------------------
 | ADD HYD   (0006) |
 |   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
 --------------------          (ha)     (cms)    (hrs)     (mm)
           ID1= 1 (0001):    11.40   0.680     4.00    21.50
         + ID2= 2 (0003):     9.70   0.760     4.17    39.46
           ================================================
           ID = 3 (0006):    21.10   1.277     4.08    29.76

      NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
 --------------------
 | CALIB            |
 | NASHYD    (0002) |   Area     (ha)=   2.50   Curve Number   (CN)= 54.0
 |ID= 1 DT= 5.0 min |   Ia       (mm)=  16.20   # of Linear Res.(N)= 3.00
 --------------------   U.H. Tp(hrs)=   0.11

      Unit Hyd Qpeak  (cms)=   0.853

      PEAK FLOW       (cms)=   0.126 (i)
      TIME TO PEAK    (hrs)=   4.083
      RUNOFF VOLUME    (mm)=  22.242
      TOTAL RAINFALL   (mm)=  98.403
      RUNOFF COEFFICIENT   =   0.226

      (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
 --------------------
 | CALIB            |
 | NASHYD    (0004) |   Area     (ha)=  12.20   Curve Number   (CN)= 69.0
 |ID= 1 DT= 5.0 min |   Ia       (mm)=   8.60   # of Linear Res.(N)= 3.00
 --------------------   U.H. Tp(hrs)=   0.26

      Unit Hyd Qpeak  (cms)=   1.806

      PEAK FLOW       (cms)=   0.787 (i)
      TIME TO PEAK    (hrs)=   4.250
      RUNOFF VOLUME    (mm)=  39.520
      TOTAL RAINFALL   (mm)=  98.403
      RUNOFF COEFFICIENT   =   0.402

      (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------

 --------------------
 | ADD HYD   (0007) |
 |   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
 --------------------          (ha)     (cms)    (hrs)     (mm)
```

```
          ID1= 1 (0002):     2.50   0.126     4.08    22.24
        + ID2= 2 (0004):    12.20   0.787     4.25    39.52
          ==================================================
          ID = 3 (0007):    14.70   0.862     4.25    36.58

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD  (0008) |   Area    (ha)=   9.80
|ID= 1 DT= 5.0 min |   Total Imp(%)=  47.00   Dir. Conn.(%)=  47.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       4.61         5.19
     Dep. Storage     (mm)=       1.00        10.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     255.60        40.00
     Mannings n           =      0.013        0.250

     Max.Eff.Inten.(mm/hr)=     237.13        25.21
                over (min)        5.00        20.00
     Storage Coeff.  (min)=       3.18 (ii)   15.42 (ii)
     Unit Hyd. Tpeak (min)=       5.00        20.00
     Unit Hyd. peak  (cms)=       0.27         0.07
                                                                *TOTALS*
     PEAK FLOW       (cms)=       2.51         0.21          2.569 (iii)
     TIME TO PEAK    (hrs)=       4.00         4.25           4.00
     RUNOFF VOLUME    (mm)=      97.40        26.38          59.76
     TOTAL RAINFALL   (mm)=      98.40        98.40          98.40
     RUNOFF COEFFICIENT   =       0.99         0.27           0.61

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  55.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
```

# Appendix B

Preliminary SWM Pond Design

SWM Ponds were conceptually and conservatively designed using MOE methods as identified in their 2003 Planning and Design Manual.

The **Table B-1**, below, identifies the Pond dimensions and the resulting volumes required for water quality impact mitigation including Permanent Pool , Extended Detention and Emergency 100 year retention requirements.

The drawing, below, identifies conceptual pond layouts and standard inlet and outlet configurations whose dimensions and elevations will be revised and optimised during detailed design. Typically all SWM Ponds will have a Permanent Pool that is a minimum 1.0m deep and will have an additional 0.5m for extended detention and 100 year emergency storage as well as another 0.5m to 1.25m to complete emergency storage requirements.

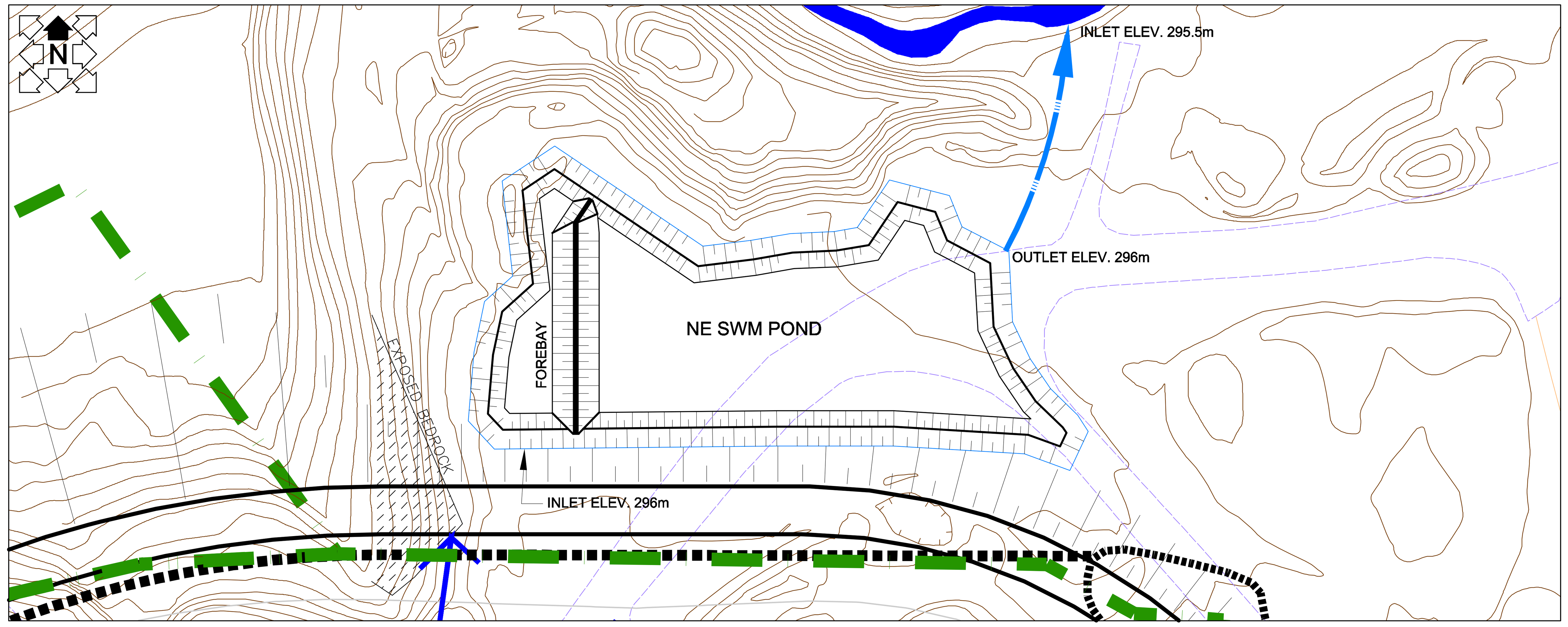
A bottom draw configuration is illustrated for thermal impact mitigation

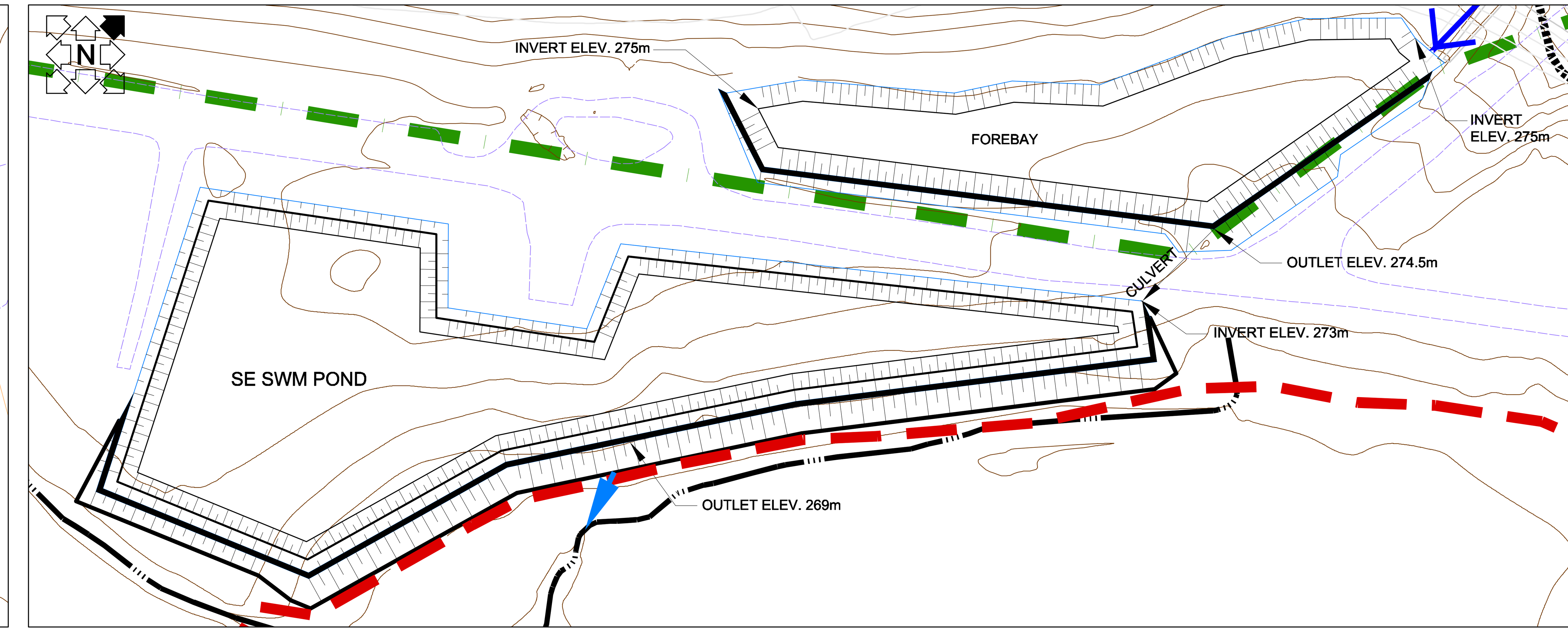
**Table B-1 SWM Pond Design - Summary**

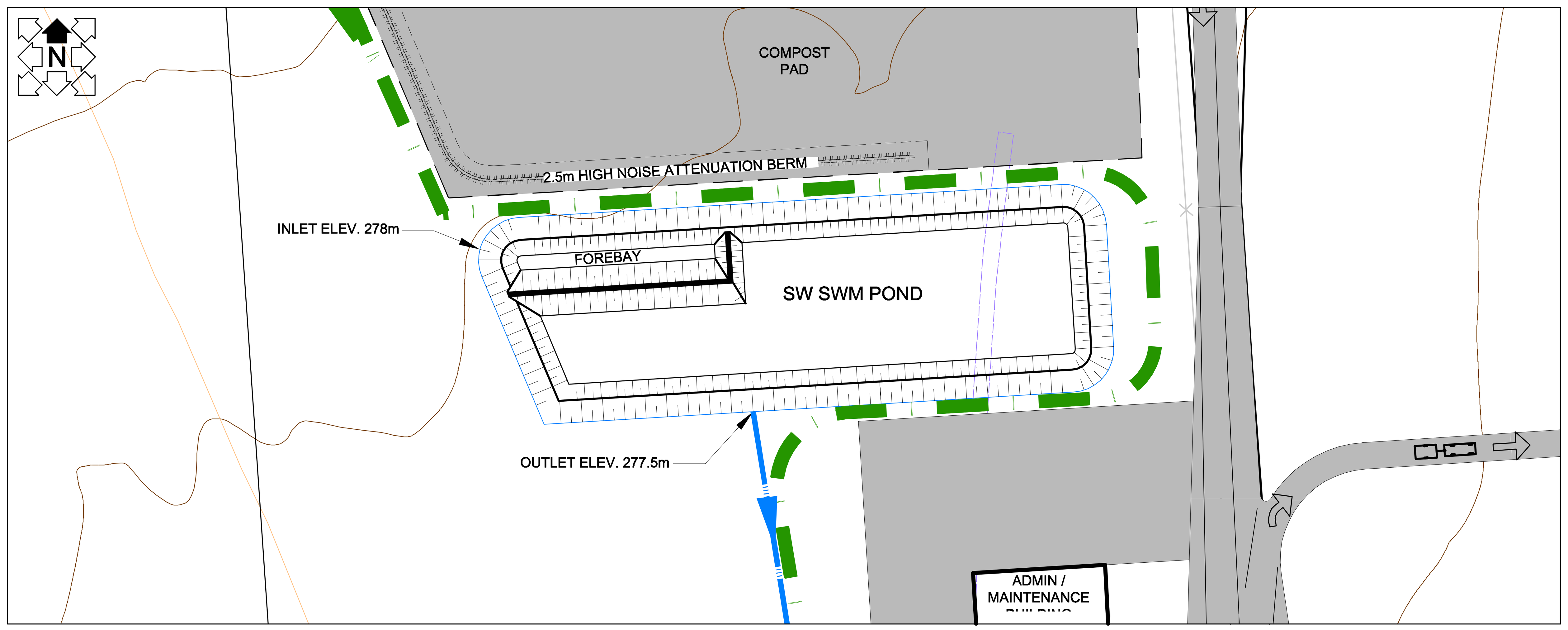
| Drainage Area (DA) ID | DA (ha) | % IMP | Design Volume Criteria ($m^3$/ha - MOE 2003) | | | Associated SWM Pond | Volume Required ($m^3$) | | | Pond Dimensions | Volume Provided ($m^3$) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | TOTAL | Permanent Pool (PP) | Extended Detention (ED) | | PP | ED | 100 Year Emergency[1.0] | LxWxD | PP | ED | 100 Year Emergency (including ED) |
| L1 | 9.7 | 35 | 140 | 100 | 40 | SW | 970 | 388 | 3831 | 115x40x2.0 | 4145 | 1750 | 4635 |
| L2 | 12.2 | 35 | 140 | 100 | 40 | NE | 1220 | 488 | 4819 | 100x45x2.75 | 4080 | 1735 | 5255 |
| L3 | 18.7 | 35 | 140 | 100 | 40 | SE | 1870 | 748 | 7368 | 180x40x2.5 | 6550 | 2805 | 7510 |
| L4 | 9.8 | 45 | 165 | 125 | 40 | S | 1225 | 392 | NA | 100x40x1.5 | 4560 | 1970 | NA |

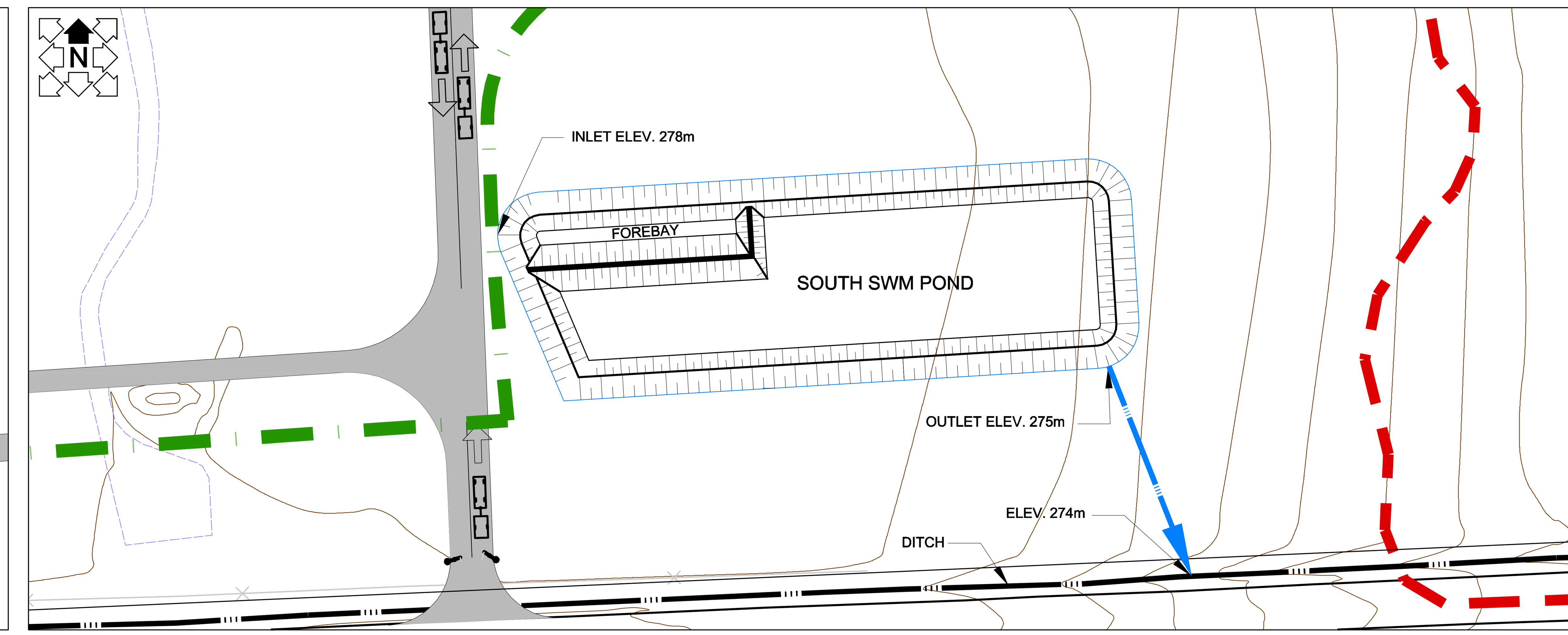
1.0 from hydrologic model

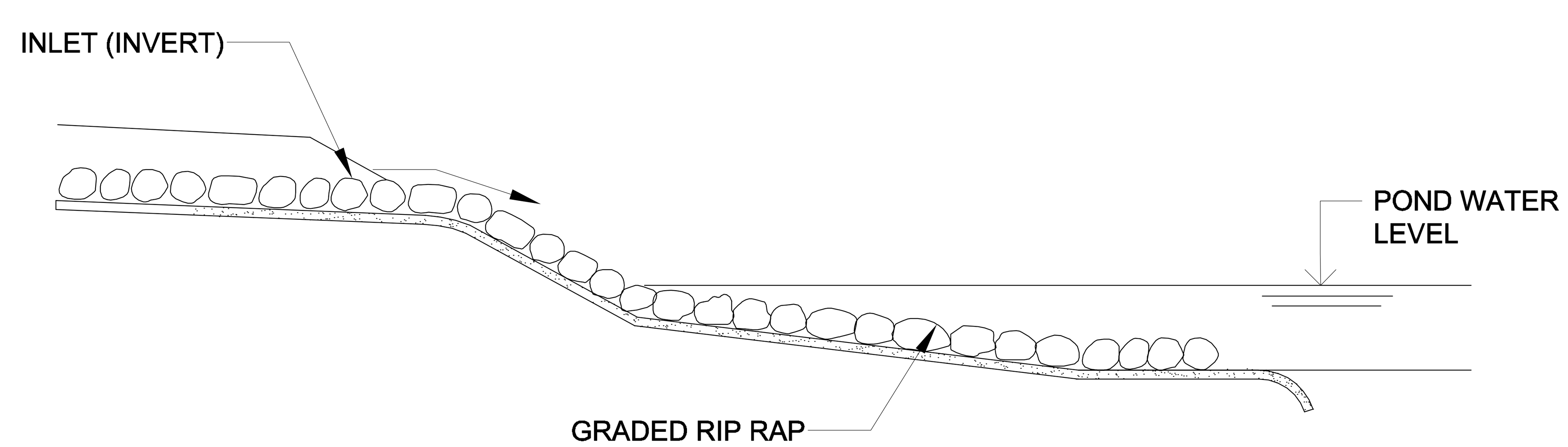
NA not applicable



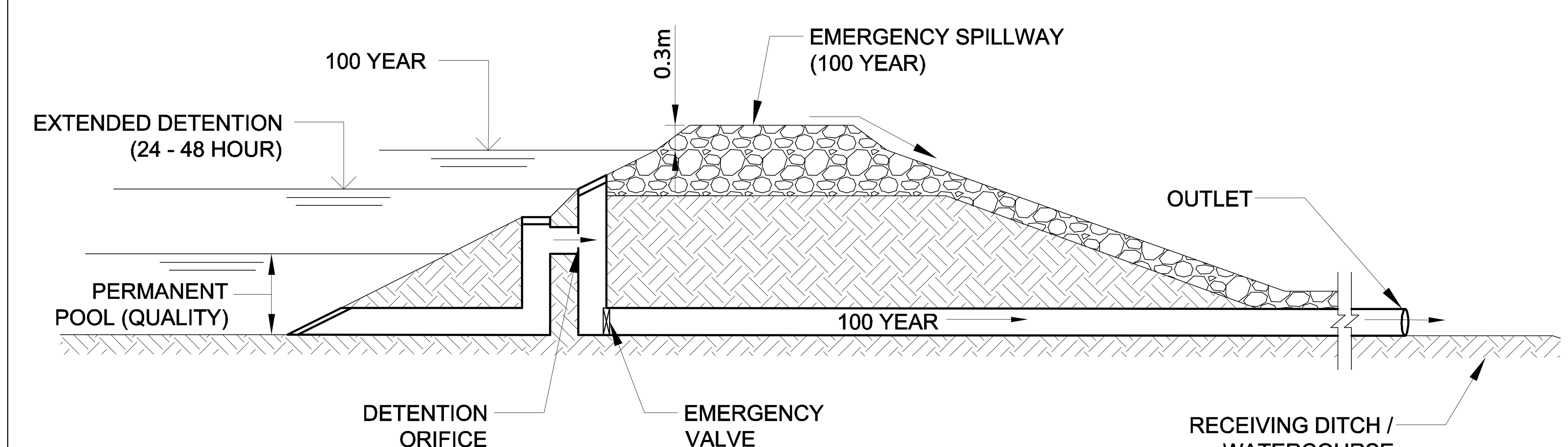




TYPICAL INLET WITH GEOTEXTILE

N.T.S.




TYPICAL OUTLET

N.T.S.


AECOM

AECOM Canada Ltd.
523 Wellington Street East, Sault Ste. Marie Ontario, Canada
P6A2M4 T705.942.2612 F705.942.3642


# STORMWATER MANAGEMENT PONDS

## Sault Ste. Marie Municipal Landfill Site

THE CORPORATION OF THE CITY OF SAULT STE. MARIE, ONTARIO
ENGINEERING DEPARTMENT

COMMISSIONER OF ENGINEERING & PLANNING
JERRY DOLCETTI

| | |
|---|---|
| SCALE HORZ. | 1:750(A1) 1:1500(11x17) |
| VERT. | |
| DATE | SEPTEMBER 2015 |
| DWG. | SAE |
| CHECKED | PF PAGE |
| FILE | |

Consultant Drawing Number

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